

## CLAIMS

What is claimed is:

- 1 1. An MRAM cell comprising:
  - 2 a magnetic tunneling junction including
    - 3 a free layer,
    - 4 a pinned layer, and
      - 5 a spacer layer disposed between the free layer and the pinned layer;
    - 6 a digit line including a bit line segment disposed proximate to the magnetic
      - 7 tunneling junction;
    - 8 a bit line including a bit line segment in electrical contact with the magnetic
      - 9 tunneling junction; and
    - 10 a magnetic liner layer disposed around the bit line segment and contacting the free
      - 11 layer.
  - 1 2. The MRAM cell of claim 1 wherein the digit line segment is disposed proximate to
    - 2 the pinned layer and the bit line segment is in electrical contact with the free
      - 3 layer.
  - 1 3. The MRAM cell of claim 1 wherein the bit line segment is disposed proximate to the
    - 2 pinned layer and the digit line segment is in electrical contact with the free layer.
  - 1 4. The MRAM cell of claim 1 wherein the magnetic liner layer is electrically conductive.

1       5. The MRAM cell of claim 1 wherein the bit and digit lines are formed of a metal  
2                   selected from the group consisting of Cu, W, and Al.

1       6. The MRAM cell of claim 1 further including an antiferromagnetic layer disposed  
2                   adjacent to the pinned layer.

1       7. The MRAM cell of claim 1 wherein the magnetic liner layer is formed of Permalloy.

1       8. The MRAM cell of claim 7 wherein the Permalloy is between 16 and 22 atomic  
2                   percent iron.

1       9. The MRAM cell of claim 7 wherein the Permalloy is Ni<sub>81</sub>Fe<sub>19</sub>.

1       10. The MRAM cell of claim 1 wherein the magnetic liner layer has a thickness of about  
2                   20Å to about 500Å.

1       11. The MRAM cell of claim 1 wherein the magnetic liner layer has a thickness of about  
2                   30Å to about 100Å.

1       12. The MRAM cell of claim 1 wherein the magnetic liner layer is formed of a material  
2                   selected from the group consisting of CoZrCr, CoZrNb, CoZrRe, FeSiAl, FeN,  
3                   FeAlN, FeRhN, and FeTaN.

1 14. The MRAM cell of claim 1 wherein the free layer is two ferromagnetic layers.

1 15. An MRAM cell comprising:

2 a magnetic tunneling junction including

3 a free layer having a magnetization orientation,

4 a pinned layer, and

5 an insulating spacer layer disposed between the free layer and the pinned  
6 layer;

a digit line including a segment disposed proximate to the pinned layer;

a bit line including a segment in electrical contact with the free layer;

9           a magnetic liner layer disposed around the bit line segment and contacting the free  
10           layer such that a magnetic field encircles the bit line segment.

1 16. The MRAM cell of claim 15 wherein the magnetic liner layer is electrically  
2 conductive.

1 19. The MRAM cell of claim 15 wherein the magnetic liner layer is formed of  
2 Permalloy.

1 21. The MRAM cell of claim 19 wherein the Permalloy is Ni<sub>81</sub>Fe<sub>19</sub>.

1 25. The MRAM cell of claim 15 wherein the free layer is two ferromagnetic layers.

1        26. An MRAM cell comprising:  
2              a magnetic tunneling junction including  
3                  a free layer,  
4                  a pinned layer, and  
5                  an insulating spacer layer disposed between the free layer and the pinned  
6                  layer;  
7              a digit line including a segment disposed proximate to the pinned layer, the digit  
8                  line segment having a long axis defining a first direction;  
9              an electrically insulating spacer layer disposed between the digit line segment and  
10                 the pinned layer;  
11              a bit line including a segment in electrical contact with the free layer, the bit line  
12                 segment having a long axis defining a second direction substantially  
13                 perpendicular to the first direction;  
14              a magnetic liner layer disposed around the bit line segment and contacting the free  
15                 layer.

1        27. The MRAM cell of claim 26 wherein the magnetic liner layer is electrically  
2              conductive.

1        28. The MRAM cell of claim 26 wherein the bit and digit lines are formed of a metal  
2              selected from the group consisting of Cu, W, and Al.

1 29. The MRAM cell of claim 26 further including an antiferromagnetic layer disposed  
2 adjacent to the pinned layer.

1       30. The MRAM cell of claim 26 wherein the magnetic liner layer is formed of  
2                   Permalloy.

1 32. The MRAM cell of claim 30 wherein the Permalloy is Ni<sub>81</sub>Fe<sub>19</sub>.

1 34. The MRAM cell of claim 26 wherein the magnetic liner layer has a thickness of  
2 about 30Å to about 100Å.

1 35. The MRAM cell of claim 26 wherein the pinned layer is two ferromagnetic layers  
2 separated by a spacer layer.

1 36. The MRAM cell of claim 26 wherein the free layer is two ferromagnetic layers.

1       37. An MRAM cell comprising:

2              a magnetic tunneling junction including

3                  a free layer,

4                  a pinned layer, and

5                  an insulating spacer layer disposed between the free layer and the pinned

6                  layer;

7              a digit line including a segment disposed proximate to the pinned layer, the

8                  segment having a long axis defining a first direction;

9              a bit line including

10                 a segment in electrical contact with the free layer and having

11                 a long axis defining a second direction substantially perpendicular

12                 to the first direction,

13                 a bottom surface abutting the free layer,

14                 a top surface opposite the bottom surface, and

15                 first and second vertical surfaces opposite one another and

16                 connecting the top and bottom surfaces; and

17              a magnetic liner layer disposed around the bit line segment and contacting the

18                 first and second vertical surfaces and the top surface.

1       38. The MRAM cell of claim 37 wherein the magnetic liner layer also contacts the free

2              layer.

1       39. The MRAM cell of claim 37 wherein the magnetic liner layer is electrically  
2                   conductive.

1       40. The MRAM cell of claim 37 wherein the bit and digit lines are formed of a metal  
2                   selected from the group consisting of Cu, W, and Al.

1       41. The MRAM cell of claim 37 further including an antiferromagnetic layer disposed  
2                   adjacent to the pinned layer.

1       42. The MRAM cell of claim 37 wherein the magnetic liner layer is formed of  
2                   Permalloy.

1       43. The MRAM cell of claim 42 wherein the Permalloy is between 16 and 22 atomic  
2                   percent iron.

1       44. The MRAM cell of claim 42 wherein the Permalloy is Ni<sub>81</sub>Fe<sub>19</sub>.

1       45. The MRAM cell of claim 37 wherein the magnetic liner layer has a thickness of  
2                   about 20Å to about 500Å.

1       46. The MRAM cell of claim 37 wherein the magnetic liner layer has a thickness of  
2                   about 30Å to about 100Å.

1 48. The MRAM cell of claim 37 wherein the free layer is two ferromagnetic layers.

1 49. An MRAM cell comprising:

2 a magnetic tunneling junction including

3 a free layer,

4 a pinned layer, and

5 an insulating spacer layer disposed between the free layer and the pinned  
6 layer;

7 a digit line including a segment disposed proximate to the pinned layer, the digit  
8 line segment having a long axis defining a first direction;

9 a bit line including a bit line segment in electrical contact with the free layer and  
0 having a long axis defining a second direction substantially perpendicular  
1 to the first direction; and

12 a magnetic sheath disposed around the bit line segment and formed from the free  
13 layer and a magnetic liner layer.

1 50. The MRAM cell of claim 49 wherein the magnetic liner layer is electrically  
2 conductive.

1 51. The MRAM cell of claim 49 wherein the bit and digit lines are formed of a metal  
2 selected from the group consisting of Cu, W, and Al.

1 52. The MRAM cell of claim 49 further including an antiferromagnetic layer disposed  
2 adjacent to the pinned layer.

1 53. The MRAM cell of claim 49 wherein the magnetic liner layer is formed of  
2 Permalloy.

1 54. The MRAM cell of claim 53 wherein the Permalloy is between 16 and 22 atomic  
2 percent iron.

1 55. The MRAM cell of claim 53 wherein the Permalloy is Ni<sub>81</sub>Fe<sub>19</sub>.

1 56. The MRAM cell of claim 49 wherein the magnetic liner layer has a thickness of  
2 about 20Å to about 500Å.

1 57. The MRAM cell of claim 49 wherein the magnetic liner layer has a thickness of  
2 about 30Å to about 100Å.

1 58. The MRAM cell of claim 49 wherein the pinned layer is two ferromagnetic layers  
2 separated by a spacer layer.

1    59. The MRAM cell of claim 49 wherein the free layer is two ferromagnetic layers.

1    60. A method of fabricating an MRAM cell comprising:

2                providing a substrate;

3                forming a digit line on the substrate;

4                forming an insulating spacer including a contact via over the bit line;

5                forming a bottom lead over the insulating spacer;

6                forming a magnetic tunnel junction stack over the bottom lead;

7                forming a first liner layer over the magnetic tunnel junction;

8                forming a bit line over the magnetic tunnel junction stack; and

9                forming a second liner layer over the bit line.

1    61. The method of claim 60 wherein forming the bit line includes

2                forming and patterning an oxide layer on the substrate;

3                depositing a conductive metal; and

4                planarizing a top surface of the conductive metal.

1    62. The method of claim 61 wherein the conductive metal is selected from the group

2                consisting of copper, tungsten, and aluminum.

1    63. The method of claim 61 wherein planarizing is performed by CMP.

1       64. The method of claim 60 wherein forming the bottom lead is performed by depositing  
2            a conductive metal selected from the group consisting of copper, tungsten, and  
3            aluminum.

1       65. The method of claim 60 wherein forming the bottom lead includes a patterning step.

1       66. The method of claim 60 wherein forming the magnetic tunnel junction stack includes  
2            forming a first ferromagnetic layer over the bottom lead;  
3            forming a tunneling barrier layer over the first ferromagnetic layer; and  
4            forming a second ferromagnetic layer over the tunneling barrier layer.

1       67. The method of claim 66 wherein forming the magnetic tunnel junction stack further  
2            includes forming an antiferromagnetic layer between the first ferromagnetic layer  
3            and the bottom lead.

1       68. The method of claim 66 wherein forming the magnetic tunnel junction stack further  
2            includes forming an antiferromagnetic above the second ferromagnetic layer.

1       69. The method of claim 66 wherein forming the magnetic tunnel junction stack further  
2            includes a patterning step.

1       70. The method of claim 60 further comprising forming an insulating material layer over  
2            the insulating spacer.

1       71. The method of claim 70 wherein forming an insulating material layer includes  
2                  forming a trench therein and over the magnetic tunnel junction stack.

1       72. The method of claim 71 wherein the trench has first and second sidewalls.

1       73. The method of claim 72 wherein the first liner layer is formed on the first and second  
2                  sidewalls.

1       74. The method of claim 60 wherein the first liner layer is formed with a thickness in the  
2                  range of about 20Å to about 500Å.

1       75. The method of claim 60 wherein the first liner layer is formed by ion beam  
2                  deposition or physical vapor deposition.

1       76. The method of claim 60 wherein the first liner layer is formed of Permalloy.

1       77. The method of claim 60 further comprising forming a stop layer over the first liner  
2                  layer.

1       78. The method of claim 77 further comprising forming a seed layer over the stop layer.

1       79. The method of claim 60 wherein forming the bit line includes forming a seed layer.

1       80. The method of claim 60 wherein the bit line is formed of a conductive metal selected  
2                          from the group consisting of copper, tungsten, and aluminum.

1       81. The method of claim 60 wherein forming the bit line includes a planarization.

1       82. The method of claim 81 wherein forming the bit line includes an ion beam etch.

1       83. The method of claim 60 wherein forming the second liner layer includes  
2                          forming and patterning a mask; and  
3                          removing portions of the second liner layer.

1       84. The method of claim 60 wherein the second liner layer is formed with a thickness in  
2                          the range of about 20Å to about 500Å.

1       85. The method of claim 60 wherein the second liner layer is formed of Permalloy.

1       86. A method of fabricating an MRAM cell comprising:  
2                          providing a digit line;  
3                          forming a magnetic tunnel junction stack over the digit line;  
4                          forming a bit line; and  
5                          forming a magnetic liner layer over the bit line and in contact with the magnetic  
6                          tunnel junction stack.

1    87. The method of claim 86 wherein forming a magnetic tunnel junction stack includes  
2                 forming a free ferromagnetic layer and wherein the magnetic liner layer is formed  
3                 in contact with the free ferromagnetic layer.

1    88. A method of storing a bit of data in an MRAM cell, comprising:  
2                 pinning a magnetic orientation of a first ferromagnetic layer in a magnetic tunnel  
3                 junction;  
4                 simultaneously generating  
5                         a first write current in a digit line including segment proximate to the  
6                         magnetic tunnel junction and  
7                         a second write current in a bit line including segment proximate to the  
8                         magnetic tunnel junction, the write currents being sufficient to  
9                         produce a magnetic field capable of orienting a magnetic domain  
10                         of a second ferromagnetic layer in the magnetic tunnel junction;  
11                         and  
12                         maintaining the orientation of the magnetic field of the second ferromagnetic  
13                         layer by creating a magnetic loop around the bit line.